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NAIRAS Model transition to the CCMC

real-time dosimetric output and low-Earth orbit applications

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Fundings from various NASA projects: human space exploration, NASA Heliophysics

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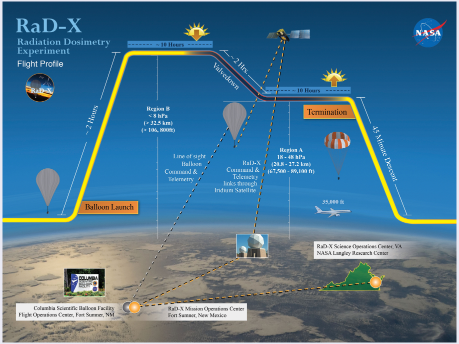
January 2022

Introduction

GCR/SEP in the solar system (and beyond)

- Studies of ionizing radiation in both space science /radioprotection and pure atmospheric research.
- Effects on human body (at Earth, Mars, . . .)
- Effects on atmospheric chemistry (Early Earth, Titan, exoplanets)
- Effects on comets and asteroids: space weathering. (Impact on our understanding from observations).

Radiation environment (RaD-X campaign 2015)



Introduction

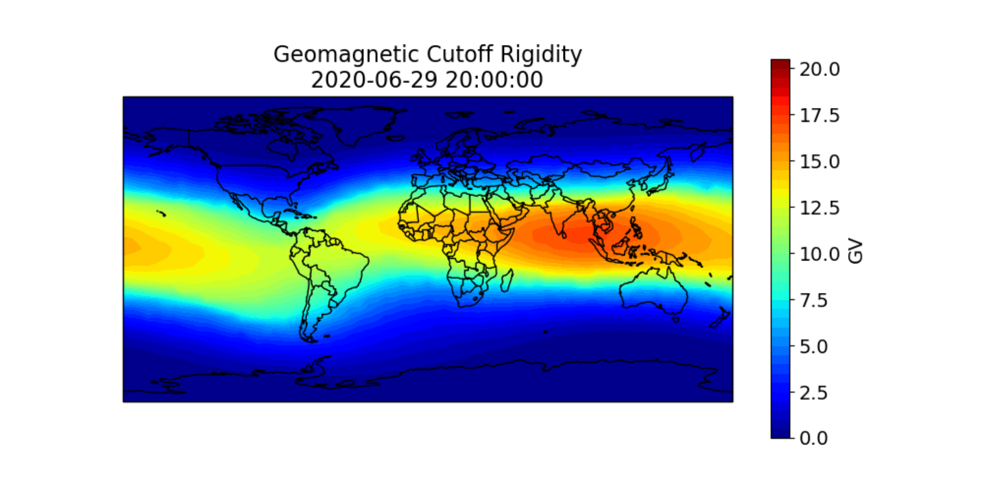
Tools used by our team

- The NAIRAS (Nowcast of Atmospheric Ionizing Radiation for Aviation Safety) model (Mertens et al.) for fast computation of GCR and SEP events.
- The PLANETOCOSMICS model (Desorgher et al.) for accurate computation of GCR and SEP events.
- The AEROPLANETS model (Gronoff et al.) for fast and accurate computation of low energy events (photons, electrons (keVs), protons (up to MeV)).

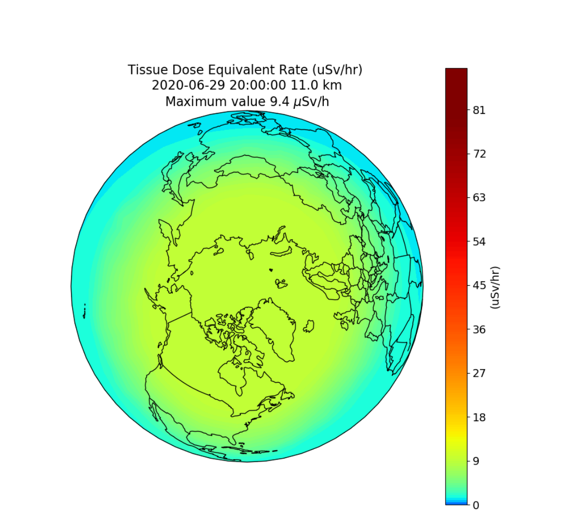
Comparison of the NAIRAS and PLANETOCOSMICS models: the NAIRAS model is fast, but has approximations on the physics, whereas PLANETOCOSMICS is more accurate, but much slower (Monte-Carlo model)

Part 1: NAIRAS, understanding the particle impact in a magnetized environment

NAIRAS: How to compute the GCR and Cosmic rays effects at Earth?



NAIRAS: How to compute the GCR and Cosmic rays effects at Earth?



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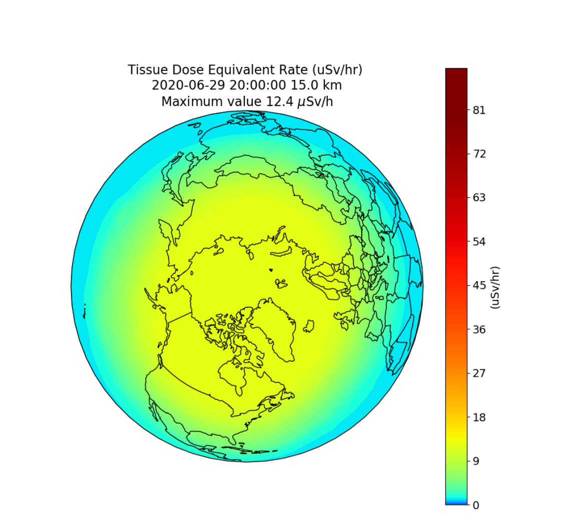

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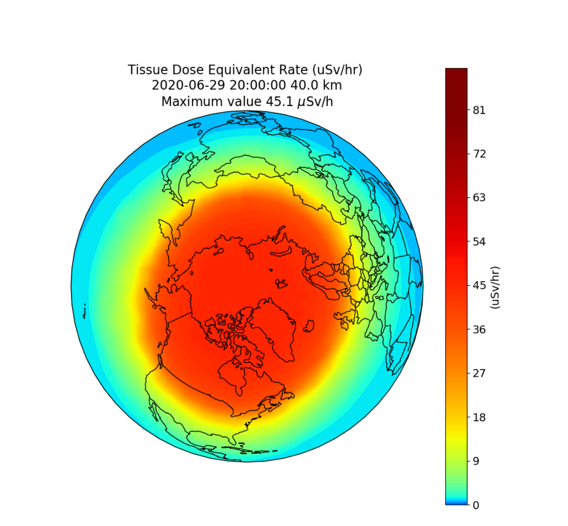
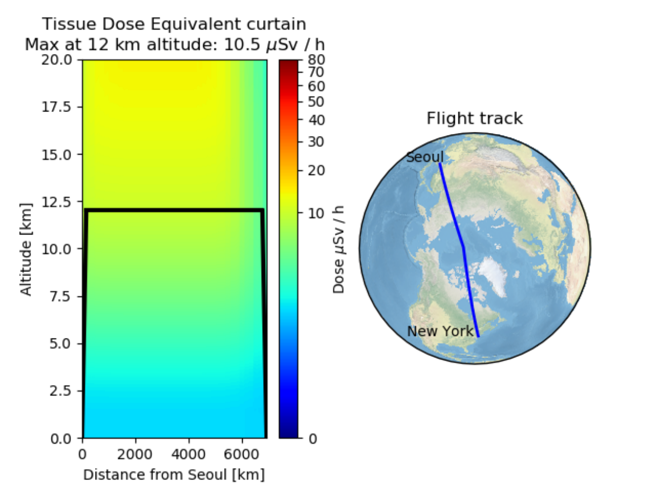


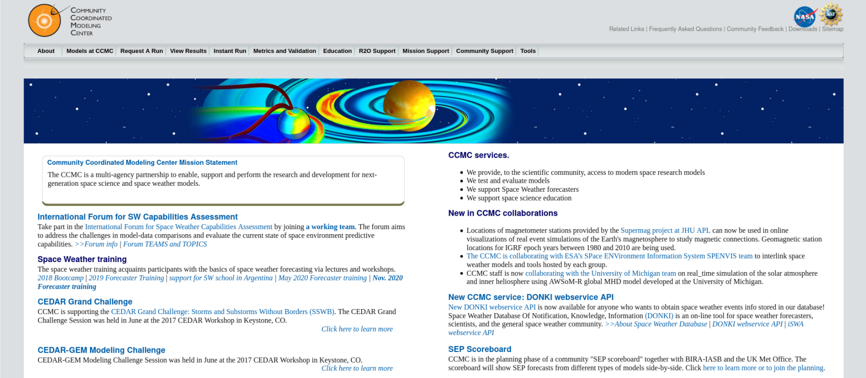
NAIRAS: How to compute the GCR and Cosmic rays effects at Earth?



Part 2: towards a spaceweather tool, NAIRAS at the CCMC, LEO NAIRAS

Adaptation of NAIRAS to the CCMC (Community Coordinated Modeling Center)

What is the CCMC


Community Coordinated Modeling Center

Related Links | Frequently Asked Questions | Community Feedback | Downloads | Sitemap

About | Models at CCMC | Request A Run | View Results | Instant Run | Metrics and Validation | Education | R2O Support | Mission Support | Community Support | Tools

Community Coordinated Modeling Center Mission Statement

The CCMC is a multi-agency partnership to enable, support and perform the research and development for next-generation space science and space weather models.

International Forum for SW Capabilities Assessment

Take part in the International Forum for Space Weather Capabilities Assessment by joining **a working team**. The forum aims to address the challenges in model-data comparisons and evaluate the current state of space environment predictive capabilities. *>>Forum info* | *Forum TEAMS and TOPICS*

Space Weather training

The space weather training acquaints participants with the basics of space weather forecasting via lectures and workshops. *2018 Bootcamp* | *2019 Forecaster Training* | *support for SW school in Argentina* | *May 2020 Forecaster training* | ***Nov. 2020 Forecaster training***

CEDAR Grand Challenge

CCMC is supporting the CEDAR Grand Challenge: Storms and Substorms Without Borders (SSWB). The CEDAR Grand Challenge Session was held in June at the 2017 CEDAR Workshop in Keystone, CO.

Click here to learn more

CEDAR-GEM Modeling Challenge

CEDAR-GEM Modeling Challenge Session was held in June at the 2017 CEDAR Workshop in Keystone, CO.

Click here to learn more

CCMC services.

- We provide, to the scientific community, access to modern space research models
- We test and evaluate models
- We support Space Weather forecasters
- We support space science education

New in CCMC collaborations

- Locations of magnetometer stations provided by the Supermag project at JHU APL can now be used in online visualizations of real event simulations of the Earth's magnetosphere to study magnetic connections. Geomagnetic station locations for IGRF epoch years between 1980 and 2010 are being used.
- The CCMC is collaborating with ESA's SPace ENVironment Information System SPENVIS team to interlink space weather models and tools hosted by each group.
- CCMC staff is now collaborating with the University of Michigan team on real_time simulation of the solar atmosphere and inner heliosphere using AWSoM-R global MHD model developed at the University of Michigan.

New CCMC service: DONKI webservice API

New DONKI webservice API is now available for anyone who wants to obtain space weather events info stored in our database! Space Weather Database Of Notification, Knowledge, Information (DONKI) is an on-line tool for space weather forecasters, scientists, and the general space weather community. *>>About Space Weather Database* | *DONKI webservice API* | *iSWA webservice API*

SEP Scoreboard

CCMC is in the planning phase of a community "SEP scoreboard" together with BIRA-IASB and the UK Met Office. The scoreboard will show SEP forecasts from different types of models side-by-side. Click here to learn more or to join the planning.

Adaptation of NAIRAS to the CCMC (Community Coordinated Modeling Center)

Challenges

- LaRC/GSFC computer communications
- Installing a software "blind"
- Implementing the best practice for software development between different group of researchers
- Version control system is fortunately helping!
- Real-time means different data sources that have their own challenges (change of format, change of NOAA/GOES satellite)

Adaptation of NAIRAS to the CCMC (Community Coordinated Modeling Center)

NAIRAS at CCMC

https://bit.ly/NAIRAS-products Link

- This is the "realtime" version
- Time in UTC, about 2h from "actual" time
- (1h for satellite data to come, 1h to process)
- Prediction is under development (ROSES-Heliophysics-O2R)

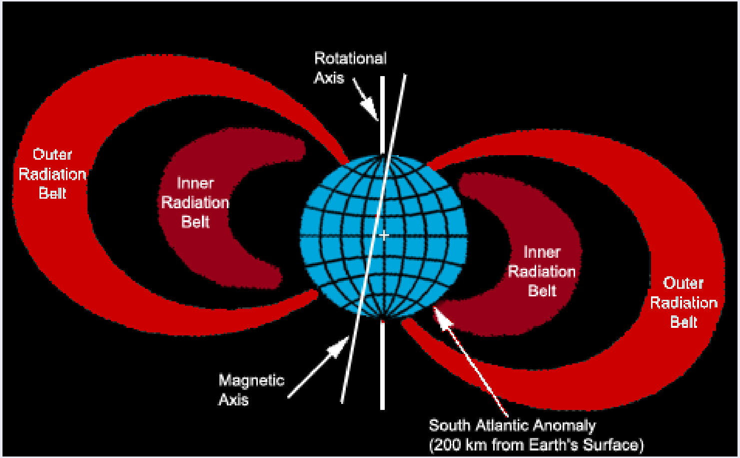
Adaptation of NAIRAS to the CCMC (Community Coordinated Modeling Center)

Run-On-Request

- Currently only text file
- Being tested for release
- Allows to input a flight/spaceflight trajectory and retrieve the dosimetric parameters
- Two main objectives:
  1. Understand the crews/missions historical exposure to radiation
  2. Estimating the probability of SEE events for hardware development
- The adaptation to LEO requires to address the radiation from the Van Allen belts

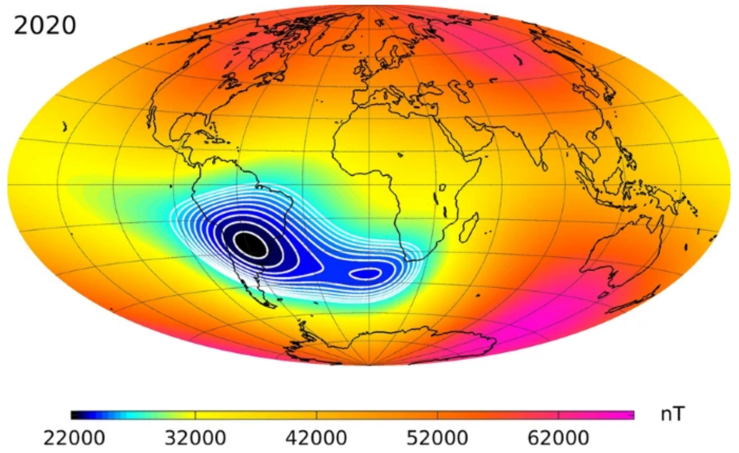
Adaptation to the Low Earth Orbit

The Van-Allen belts



Adaptation to the Low Earth Orbit

The South-Atlantic Anomaly



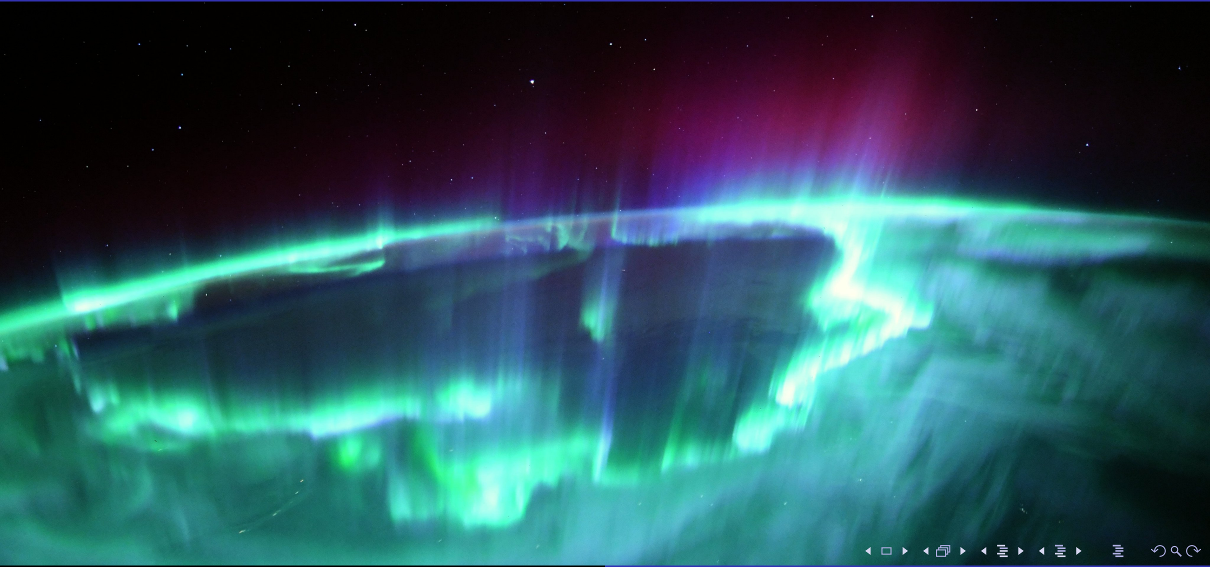
Finlay et al. 2020

Adaptation to the Low Earth Orbit

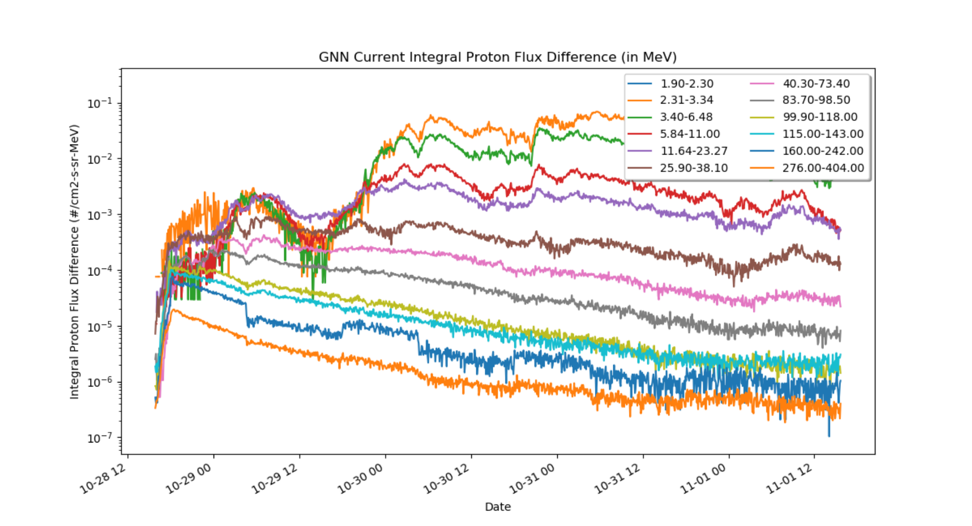
Space and sub-orbital trajectories challenges

- Inclusion of a radiation belt model
- Computation of the Cutoff rigidity in function of altitude
- Computation in and out of the atmosphere
- Shielding by aluminum

Part 3: A big event to test it all! The SEP event of Halloween 2021



The SEP event of 2021 October 28: testing the new GOES



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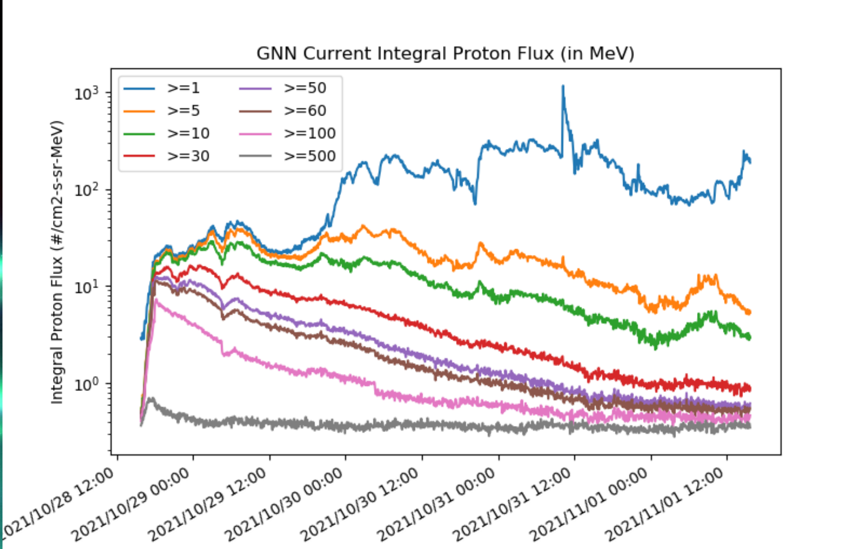

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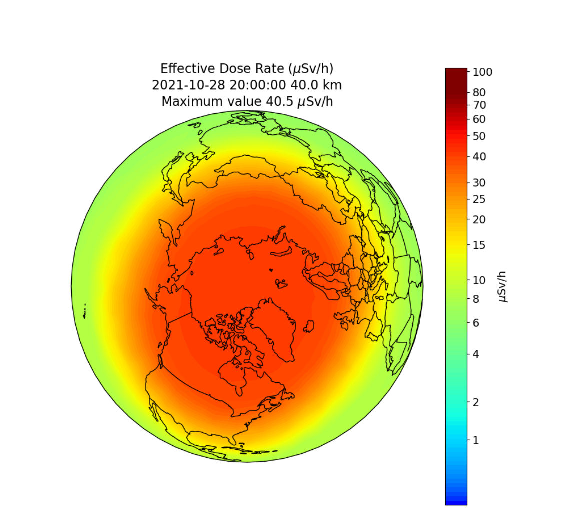

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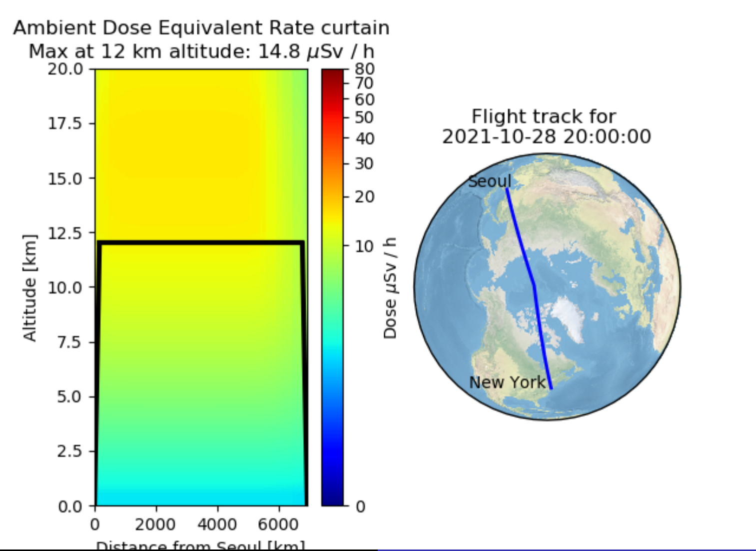

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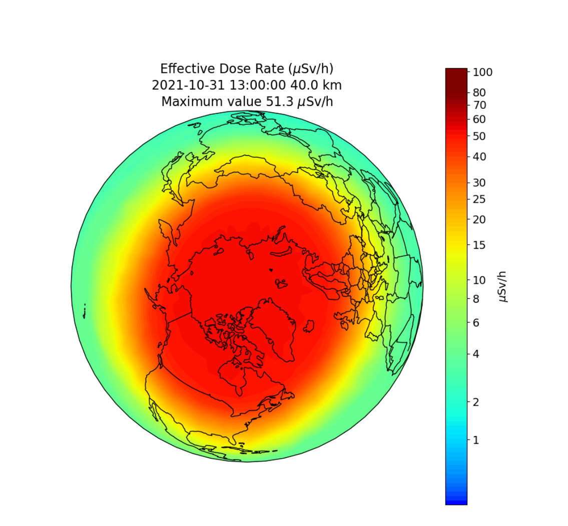
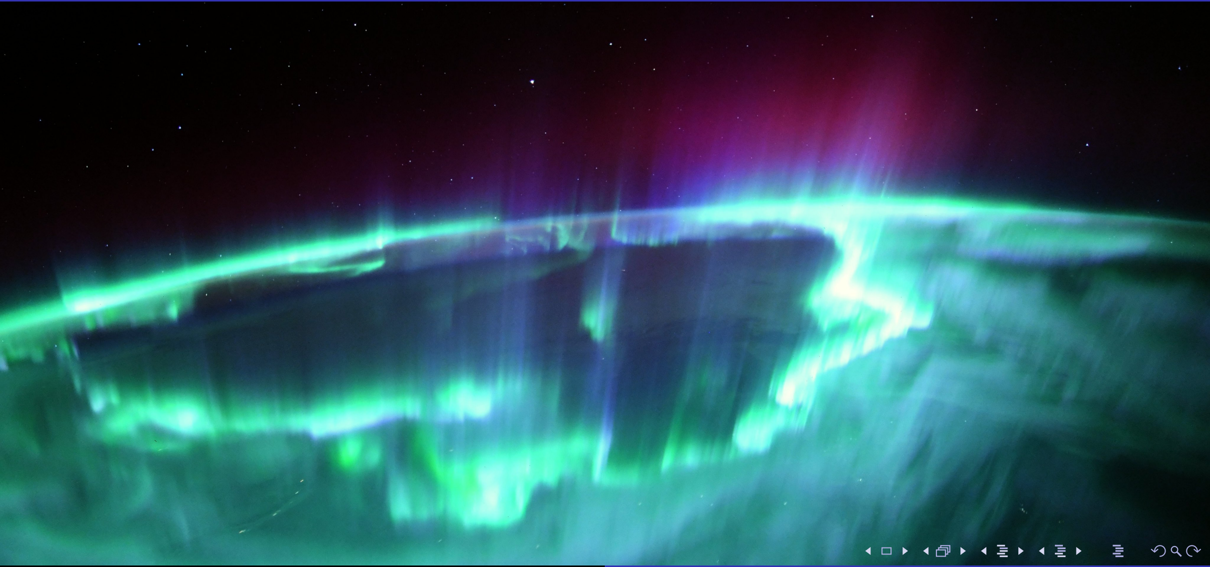


Conclusions for the human part

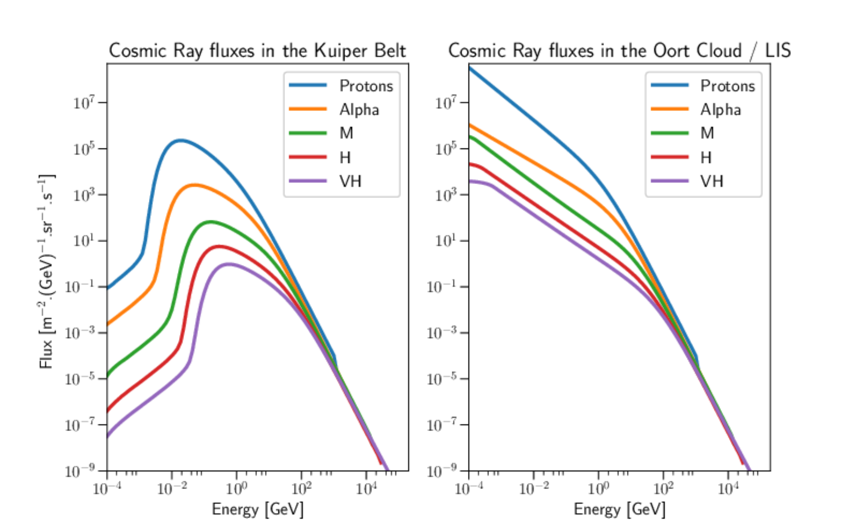
Conclusions

- The implementation of NAIRAS to the CCMC is underway and has passed several important steps
- Future work involve working with the historical SEP events (which are complex because it require the use of different generation of satellites, each with their own challenges)
- O2R work is underway to "close the gap", i.e. when satellites were not able to transmit
- O2R aims at predicting future SEP events

Extra



Application to comets (Gronoff et al. 2020; Maggiolo et al. 2020)



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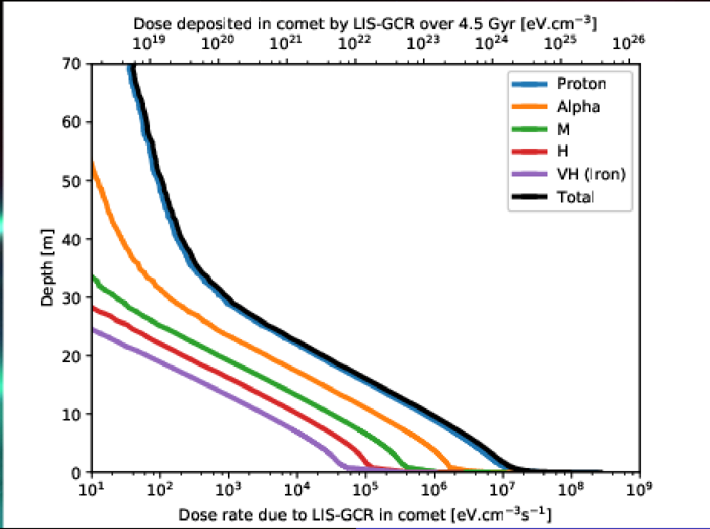

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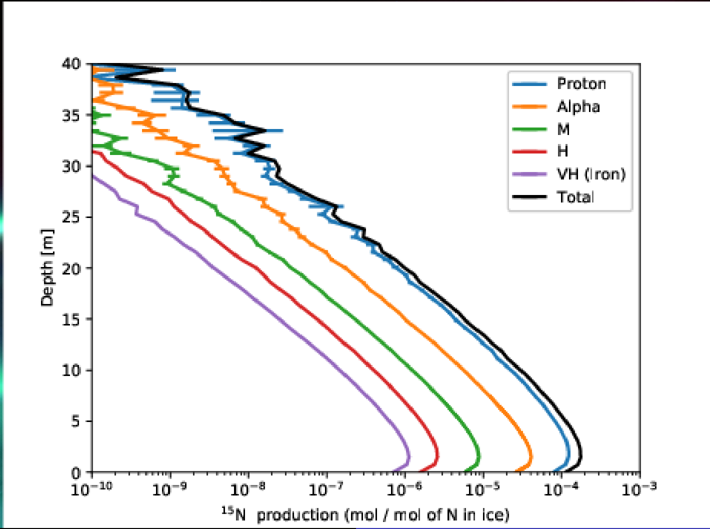
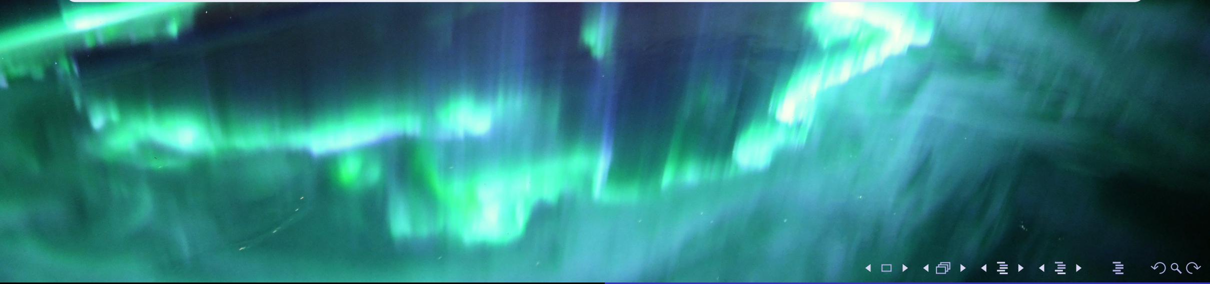


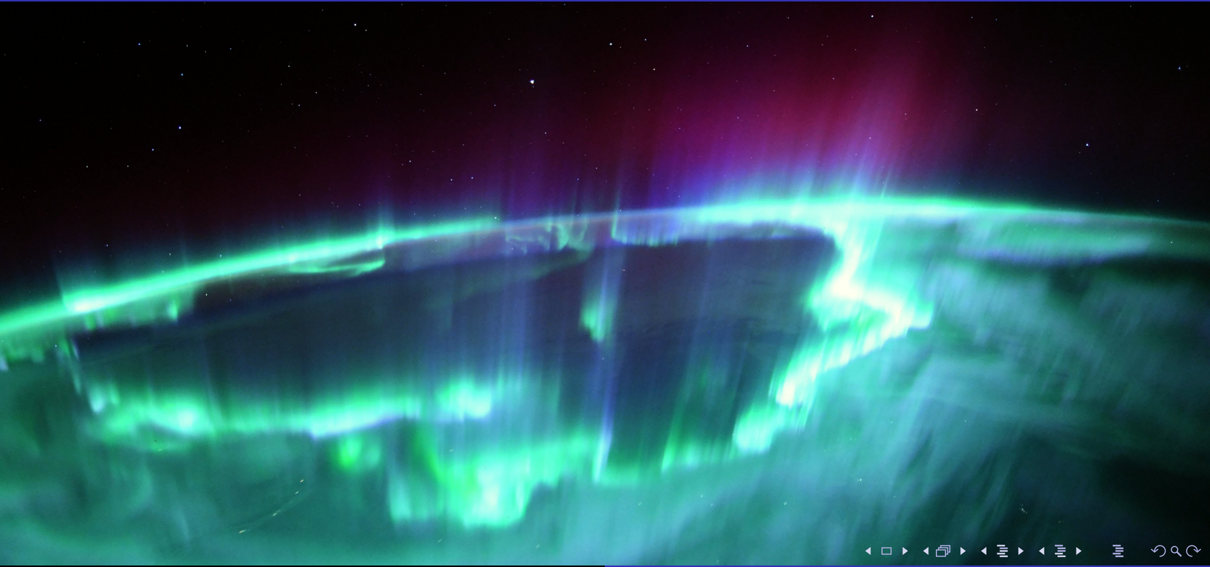
Application to planets and exoplanets

Environments of Active Stars

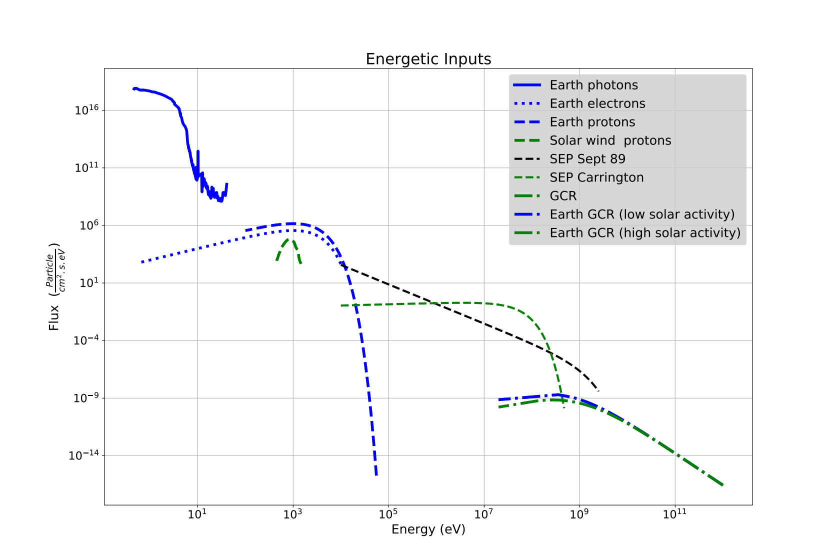
- All stars are not as quiet as our Sun.
- EUV-XUV fluxes on planets can be orders of magnitude higher.
- SEP events can be more frequent.
- The Solar Wind can put more pressure on magnetospheres.
- The Young Sun probably had a Carrington-like event every day!



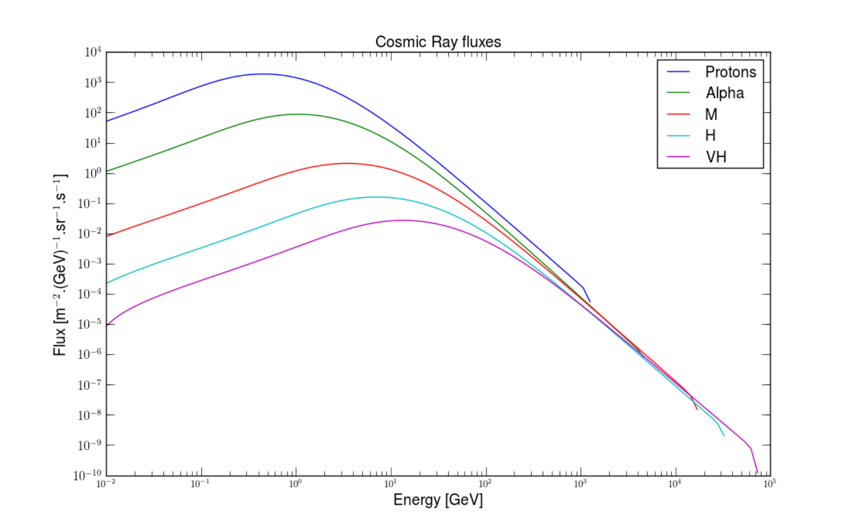
Part 1: Understanding the particle precipitation / model comparison



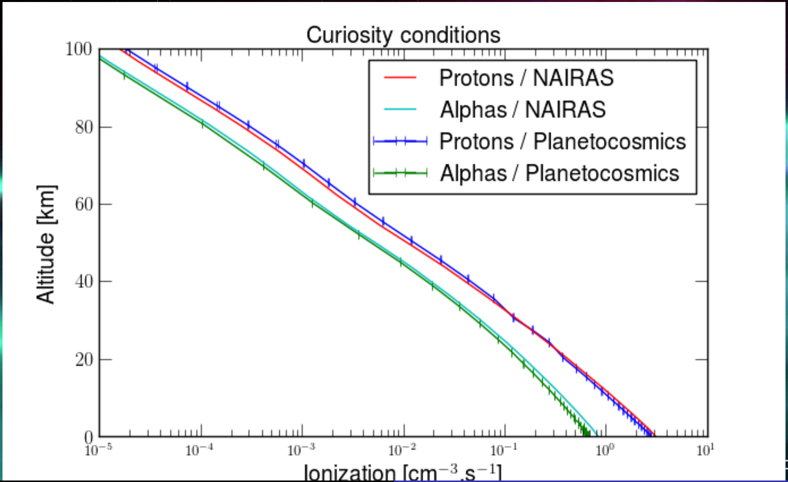
The energetic particle precipitation at Earth



The cosmic ray spectra (Detail)



The cosmic ray ionization (comparison between NAIRAS and PLANETOCOSMICS at Mars – 2015)



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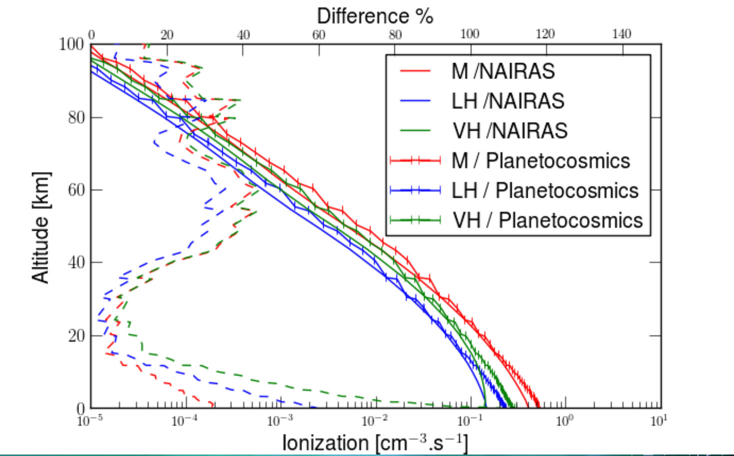
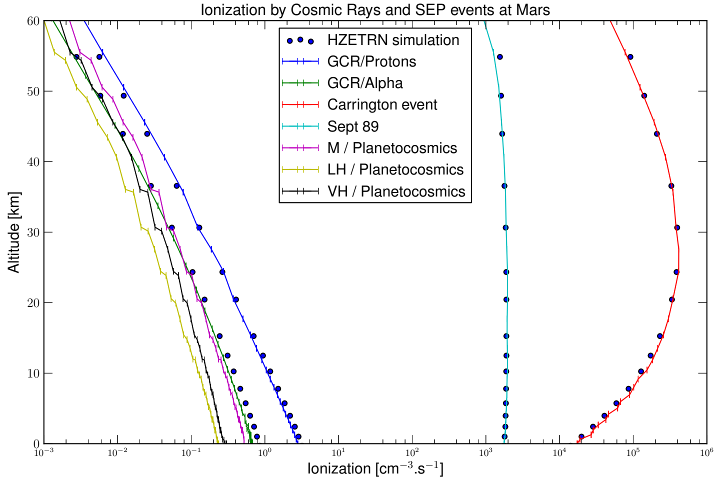


Solar energetic particle events



The dose suffered by astronauts

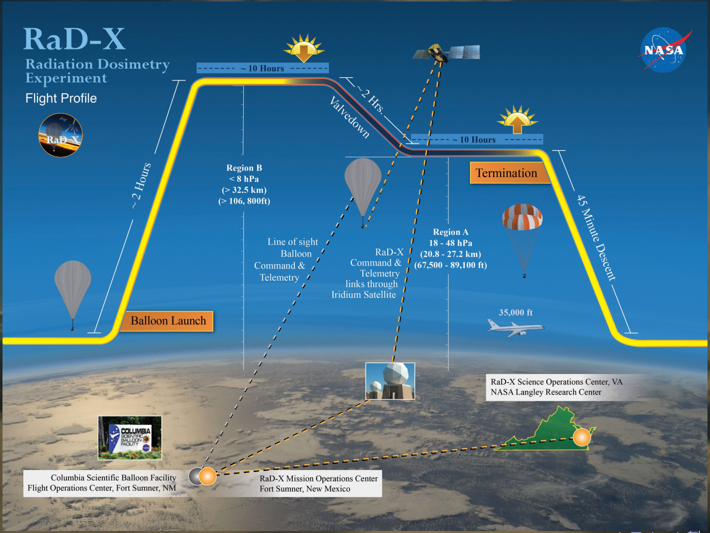
SEP events

SEP event	Planetocosmics	HZETRN
Sept 89	69.0 mGy/day	65.0 mGy/day
Carrington	755 mGy/day	502 mGy/day
Oct 22	10.4 mGy/day	9.40 mGy/day
Oct 24	20.1 mGy/day	17.5 mGy/day
SPENVIS Oct 89 5min	147 mGy/day	124 mGy/day

Galactic Cosmic Rays

GCR family	Planetocosmics computation	HZETRN
Proton	0.11 mGy/day	0.107 mGy/day
Alpha	0.023 mGy/day	0.0295 mGy/day
M	0.017 mGy/day	0.0143 mGy/day
LH	0.008 mGy/day	0.00511 mGy/day
VH	0.009 mGy/day	0.00481 mGy/day
Total	0.1670 mGy/day	0.1607 mGy/day

Part 2: Comparison with the experiment

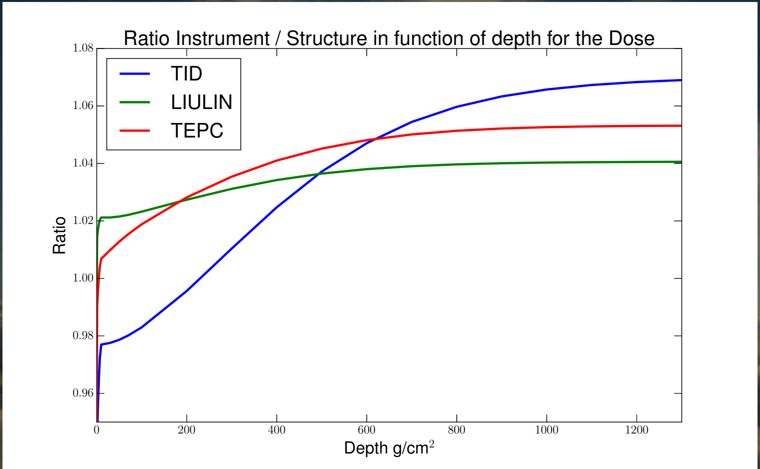

RaD-X
Radiation Dosimetry Experiment
Flight Profile
RaD-X
~ 10 Hours
~ 2 Hrs.
Valvedown
~ 10 Hours
NASA
~ 2 Hours
Region B
< 8 hPa
(> 32.5 km)
(> 106, 800ft)
Termination
Line of sight
Balloon
Command &
Telemetry
RaD-X
Command &
Telemetry
links through
Iridium Satellite
Region A
18 - 48 hPa
(20.8 - 27.2 km)
(67,500 - 89,100 ft)
45 Minute Descent
Balloon Launch
35,000 ft
RaD-X Science Operations Center, VA
NASA Langley Research Center
Columbia Scientific Balloon Facility
Flight Operations Center, Fort Sumner, NM
RaD-X Mission Operations Center
Fort Sumner, New Mexico

Mission and objectives

Mission

- PI: C. Mertens, NASA LaRC; Balloon mission,launched on Sept 25 2015
- Observation of dose using several instruments (including a TEPC) for validating cheap and light alternatives.
- Hours long measurements above the Pfotzer maximum.
- “High” altitude measurements (>32 km): dose mainly due to high-Z primary GCR particles.
- “Medium” altitude measurements (21-27 km): dose mainly due to proton and alpha primary GCR particles.
- Comparisons with the NAIRAS (and Planetocosmic) model

Correction factors of the instruments for the mission



Conclusions of the RaD-X campaign

Instruments

- The observation campaign was successful
- The correction factors allowed a comparison of the different altitudes
- More data analysis is required but: - the experiment showed the importance of pions in dose calculation

Update

Nairas has been updated with more accurate trajectory calculations and improved electromagnetic cascade, allowing an excellent comparison with the RaD-X observations.